



JRC TECHNICAL REPORT

Specifications of view services for GMES Core_003 VHR2 coverage



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1. Introduction

For the so-called DataWareHouse concept (DWH) within the GMES Initial Operations (GIO) period 2011-2014, data access management is funded through a Delegation Agreement between the EC and ESA.

The Core_003 VHR2 (GMES DWH resolution class VHR2 = 1-4m) dataset is one of the satellite coverages that are defined as CORE datasets within the DWH with fixed specifications which will be offered to a broad range of users and activities. Detailed descriptions and specifications of these CORE datasets are available in the GMES Data Access (DataWareHouse (DWH) Requirements) [1] and in the GMES Space Component Data Access Portfolio: Data Warehouse 2011-2014 [2]. The Core_003 dataset is defined as an *optical VHR2 coverage that shall be provided to cover the requirements of various services*:

a. Land applications at EU level (e.g. Urban Atlas, monitoring of coastal areas, risk areas, protected areas as Natura 2000 sites, Land Parcel Identification) and at national level;

b. Emergency response service, having the objective to have a continuous update of image archive for reference mapping.

The geographic coverage has been extended from originally planned EU 27+3 to EEA 38 countries. Thus the expected coverage area increased from approximately 4.5M km² to 7.3M km². Data collection started in early 2010 and shall be completed by end 2013.

The data licensing terms and conditions of the Core_003 VHR2 dataset foresee the possibility of a publicly available view service which will substantially increase the number of potential users. JRC was asked by DG Enterprise to provide technical specifications for the implementation of such a view service as part of the Administrative Arrangement n. 5 between DG Enterprise and JRC (AA 32362). This report is the follow up of a first draft document provided to DG Enterprise and EEA in Dec 2011 and discussed at a meeting on 13th January 2012 in Brussels [3].

This report provides an overview about different view service types with their specific characteristics and use cases. Since compliance with INSPIRE implementing rules is a goal to be achieved by GMES services, the specific requirements of INSPIRE for view services have been taken into account. The Core_003 datasets have been analysed with regard to their parameters that are important for the inclusion in view services. Based on the results of the analyses, recommendations are given for the implementation of the view services as well as for the data processing and configuration of the Core_003 datasets.

2. Data specifications

2.1. GMES Data Access Specifications

The required data specifications for the Core_003 coverage are detailed in the EC DWH Requirements document [1]. The specification parameters can be summarized as follows.

- VHR2: resolution between 1 and 4 m
- Available bands: VNIR
- Lookup table stretch: NO
- Atmospheric correction: YES
- Cloud cover: max. 5%
- Elevation angles: max. 70 degrees
- Ortho-correction with geo-location accuracy < 5 m RMSE
- Multiple sensors are allowed
- Pan-sharpening is allowed to reach the required resolution
- The non-orthorectified images should also be made available

There are some discrepancies between the specifications in the EC DWH requirements document [1] and the ESA GMES Space Component data Access Portfolio document [2] which should be clarified (see question 1 in chapter 10), and also it is of interest to understand how the Quality Control of the product is made after delivery from SPOTImage (Astrium). (See question 2 in chapter 10)

2.2. Analysis of test data

A total number of eleven scenes has been downloaded by EEA using their ESA FTP account and provided to JRC for analysis and testing. The geographic extension of the test data was Northern Italy, covering southern parts of the Po valley and northern parts of the Apennine as shown in the figure below.

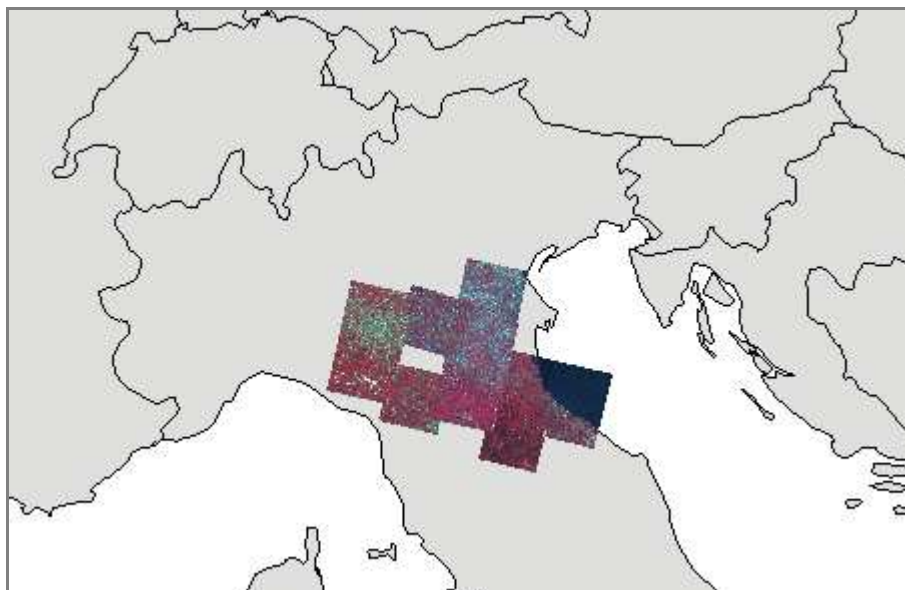


Figure 1 - Geographic coverage of test data

All scenes were Spot View products based on SPOT-5 source data. A Spot View scene is composed of two original source scenes from the two sensors HRG2 A and B. The scenes are split up into two tiles, delivered as separate dataset per tile. This seems to be the standard distribution format that SPOT Image uses to keep the maximum size of a GeoTIFF file below 2 Gigabyte. A delivery as one single tile per scene would slightly facilitate the data management and processing and still have kept the size of the GeoTIFF files below 4 Gigabyte which is the maximum size of the older GeoTIFF image library.

The datasets have been checked generically and against the parameters of the specifications.

2.2.1. Generic image information

The images are provided in ETRS89 Lambert Equal Area (LAEA) projection (EPSG 3035). Image resolution is 2.5 m per pixel. The grid layout of the scenes is starting with fractions of 1.25 m (corresponding to half the pixel size) for the upper-left corner of a pixel. This means that the grid layout has been referenced to the centre of a pixel. This is rather uncommon and the images do not align with grid layouts defined by INSPIRE. It will complicate any use of the data and the combination with other datasets that are aligned to common ETRS89 EU grid definitions. This issue must be checked with the image provider (see question 3 in chapter 10).

2.2.2. Band combination

The datasets contain three bands per TIFF file, corresponding to the SPOT 5 source bands 1 [green], 2 [red], and 3 [near infrared]. The band order of the provided scenes is [3 2 1] in relation to the original band order. A blue band is missing which affects the display possibilities. In the current band combination a direct display of the images in a view services is only possible as false colour images. This is a common approach for expert usage of satellite data and suitable e.g. for visual vegetation analysis. Due to the non-natural colours however, this will not be the most suitable display style for casual public users of a view service.

For its commercial products SPOT Image is creating an artificial blue band based on the original source bands and likely the panchromatic spectral information. This product provides pseudo-true colour image representation which is better suitable for display to casual users. This type of data has e.g. been used in big Web sites like Google Maps in the past. The technical specifications define the required bands as *VNIR* (meaning *visual + near infrared*) which can be both interpreted as *all* visible bands (blue, green, red) plus a near infrared band, as well as two visual bands plus near infrared (see question 1 in chapter 10).

The best solution would be to request from the image provider the imagery including the missing (artificial) blue band. If this is not regarded as feasible, an alternative approach for creating pseudo-true colour images is discussed in section 4.3.

2.2.3. Ortho-correction accuracy

The required geo-location accuracy of the ortho-correction process states an RMSE of 5 m or better. A detailed quality analysis will need to verify this. A quick visual correlation with a 60 cm satellite image as reference has been performed to estimate the accuracy (the specification of this reference is an RMSE of 2.5 m or better). The figure below shows road lines digitized on the 60 cm reference, overlaid on a Core_003 scene of the same area. In most cases the lines align well with the roads seen in the Core_003 scene and position accuracy seems to be in line with the specifications. An example of a larger offset is displayed in the zoomed area. This offset could be related to the usage of a surface model instead of a terrain model and a bridge in the image which can lead to this type of local distortions.

Further external geometric Quality Control could be envisaged over chosen areas where accurate check points are available (e.g. JRC test site Maussane, France) (see question 2 in chapter 10).



Figure 2 - Assessment of geo-location accuracy of a Core_003 scene towards roads digitized on a 60 cm satellite image

2.2.4. Spectral information and data lineage

The data lineage can be estimated from the provided images and experience in managing SPOT imagery data. The Core_003 orthorectified Spot View data are based on source data with 5 m resolution for pan and 10 m resolution for multispectral bands. The 2.5 m scenes are generated via oversampling and pan-merging algorithms. These processing steps however strongly influence the image information and possibility of usage.

As displayed in the figure below, originally homogeneous areas show an artificial grainy surface, stemming from the various image processing and generation steps. Due to the pan-merging process, objects like roads can show colour information not far from, e.g., some vegetation spots. These spectral degradations make an automated image interpretation or classification based on spectral information unsuitable. The main usage of the datasets will therefore be directed towards visual interpretation or background information for other geo-data.

Although not look-up-table (LUT) stretched, the histograms of the available datasets show already some modifications and partial stretching with regard to standard SPOT scenes. This is most likely related to the pan-sharpening process. A description of the data lineage, with processing history and algorithms applied, shall be requested from the data provider to access the suitability for specific use cases.

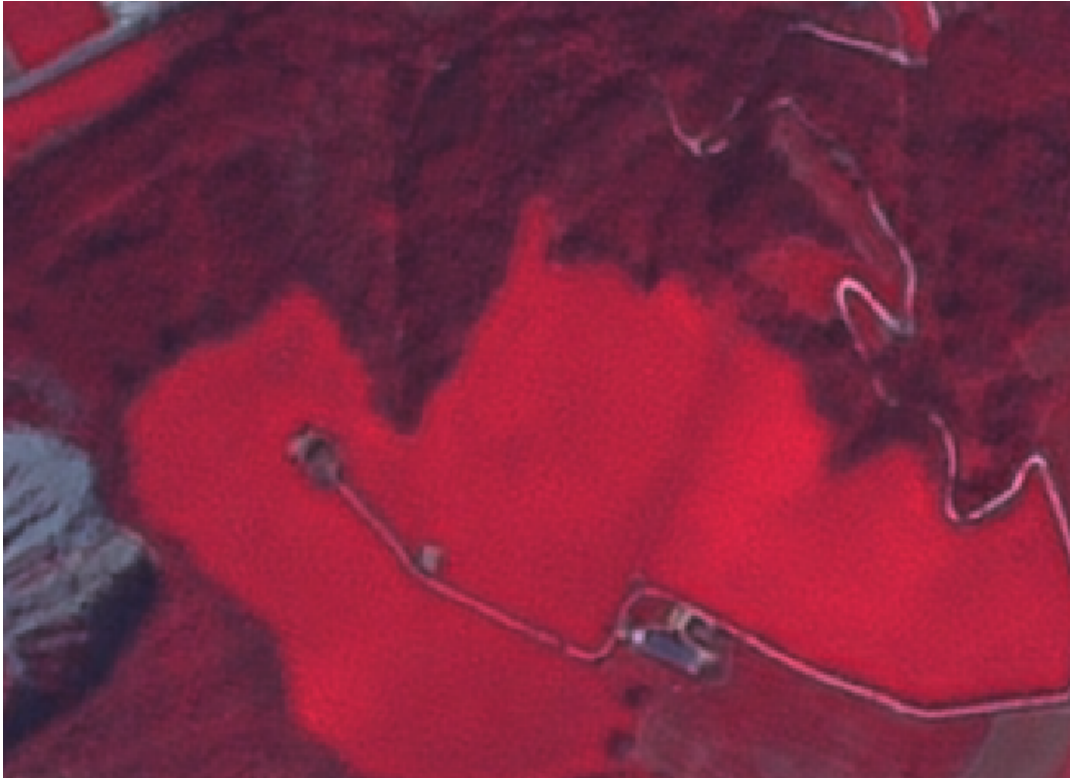


Figure 3 - Assessment of spectral information of the images

3. Definition and types of view services

In generic terms, view services in the context of geo-spatial data shall allow users to remotely view the data hosted on a central site via Internet protocols. View services do not allow direct access to the data. They just provide a pictorial representation of the data to the user.

Based on the means of usage and the service set up, three types of potential view services can be identified:

1. Web Map Service (WMS)
2. Tile service
3. Web mapping application (or Web viewer)

3.1. Web Map Service

A Web Map Service (WMS) is a standardized protocol for serving geo-referenced map images over the Internet that are generated by a Web map server and that are based on geo-spatial datasets [4]. The WMS is based on specifications [5] defined by the Open Geospatial Consortium (OGC) [6]. Although various protocol implementations exist, the only one so far having a wider usage is the implementation based on the HTTP protocol using GET and POST requests.

Any client application that implements the WMS protocol specifications in the same way can access the WMS view service and load the map images produced by the WMS server into the client. Most of recent desktop GIS software programs can act as a WMS client application and have the functionality to access data disseminated via a WMS server. This way the remote data served via WMS can be combined with locally stored geographical datasets or with data coming from another WMS.

Usage of WMS is not limited to desktop clients. Data offered via WMS can also be accessed and displayed in dedicated Web mapping applications. In addition, other WMS servers can request map images from a remote WMS and overlay them with locally stored geo-data and serving the merged product again via the WMS protocol, thus acting as “cascading WMS”.

The WMS standard focuses on flexibility in the client request enabling clients to obtain exactly the final image they want. A WMS client can request that the server creates a map by overlaying an arbitrary number of the map layers offered by the server, over an arbitrary geographic bound, with an arbitrary background colour at an arbitrary scale, in any supported coordinate reference system. [7]

Due to its widely spread implementation and versatility, the WMS is regarded as the most important implementation of a view service in the context of the Core_003 data.

3.2. Tile service

A tile service is based on the concept of serving map images as multiple tiles following standardized tiling schemes for geographic position (x, y) and predefined scale levels (z). The first important definition of a tiling scheme was introduced by Google Maps, other commercial providers like Microsoft (Bing Maps) or Yahoo implemented their own tile services with similar schemes. Also the biggest open source geo-data pool, OpenStreetMap, provides its tile services in a compatible scheme. The projection Spherical Mercator (EPSG 3857 / 900913), scale levels, and grid layout of these mentioned tile service providers are identical; they just use different notations of the x/y/z parameters for the tile requests.

A more generic approach of a tile service is the Web Map Tile Service (WMTS) [7] defined by OGC. This service can offer custom tile schemes and various coordinate reference systems and advertises the service parameters in its capabilities in the service metadata.

The advantage of using a standardized tiling scheme is the possibility of pre-rendering tiles and storing them on the file system instead of rendering the map images on-the-fly following a client request (e.g. using the WMS request specifications). The map server can then serve static tiles to the client which is by far more efficient than having to render geographic data into map images for every single request. This way a single web server can serve much more clients contemporaneously than e.g. a WMS server. The OGC specification mentions this advantage as: *WMTS trades the flexibility of custom map rendering for the scalability possible by serving of static data (base maps) where the bounding box and scales have been constrained to discrete tiles.* [7]

The disadvantage of a tile service is that it is bound to a limited set of tiling schemes and coordinate reference systems. It is therefore much less flexible than a WMS service. Support for using tile services in desktop clients is less common, but it is the best alternative to WMS for accessing geo-data via Web mapping applications.

3.3. Web mapping application

A Web mapping application can be described as a Web application providing viewing access to geo-data from within a Web browser. It is not a view service from a purely technical point of view, but it serves casual users who want to view geo-data just from inside a Web browser. It is therefore included in the recommendations as possible service implementation. The probably most known and used Web mapping application is Google Maps.

Web mapping applications are accessing geo-data via remote protocols, like the WMS or tile services mentioned above, or use locally installed rendering engines. A Web mapping application can also be regarded as a kind of wrapper application on top of standardized view service protocols.

4. Image pre-processing and layer types

4.1. Mosaicking

The analysed images show very homogeneous histogram information for scenes from the same satellite path. Inside of the same path the images are also from the same date. Neighbouring scenes from different paths however can show big differences in the spectral information. This is mostly related to seasonal effects in the land cover. The differences are causing strong boundary effects of the scenes from different paths. This can be seen clearly in the figure below.



Figure 4 - Overview about test scenes

For a scientific-oriented analysis approach the sharp boundaries between adjacent scenes do not matter. For a display towards casual users, however, scenes without clearly visible borders between scenes would be more preferable. This can potentially be achieved via different mosaicking approaches.

One approach is a histogram harmonization for all images. This could be performed via look up table (LUT) harmonization. The difficulty is to identify scenes whose histograms can be defined as the reference histogram. The application of purely LUT stretching parameters to the images could have the advantage that after the calculation of the LUT for every dataset, the stretching could be applied on the fly by the view service software. This would avoid the necessity of permanently reprocessing all images every time new images will be added to the mosaic. Due to the seasonal differences between the images this approach will not be able to fully remove the sharp borders. Blending effects between images could be applied to reduce, but not completely eliminate the sharp boundaries. This usage of blending techniques has the disadvantage of frequently reprocessing the full mosaic when new images will be added as the blending cannot be applied via simple LUT parameters.

An alternative approach could be a mosaicking algorithm that tries to delineate natural boundaries in the images, like forests, lakes, rivers, etc. The images could then be clipped along these boundaries. With an additional blending in a buffer zone along the clipping boundaries sharp transitions between scenes could be avoided and will give the mosaic a “cleaner” look. This processing however is re-

source intensive and requires processing clusters to run the mosaicking in acceptable time scales. In addition, the mosaicking algorithm of this approach needs to be capable of handling data with already applied processing steps of oversampling and pan-merging as it is the case for the Core_003 data. It would be needed to test with a block of scenes if this mosaicking approach is feasible with the Core_003 datasets. (Question 5 see Chapter 10)

Since any mosaicking approach will require computation-intensive data processing steps, this processing cannot be run every time a few new datasets have been made available. A possibility to deal with this situation could be a two-fold approach: full reprocessing of all scenes will only be applied after e.g. one third or the first half of the datasets will be available. In the meantime, additional scenes can be added to the view service without any pre-processing as separate layers that are updated more frequently. The feasibility of this approach, also its extension towards the tile services, needs to be thoroughly analyzed. Any usage of mosaicking will clearly increase the amount of data management activities and storage requirements due to creation and handling of temporary and additional product types.

4.2. False colour layer

The default band combination of the Core_003 datasets provides a false colour representation as mentioned above. This band combination is very well suited for identification and distinction of green vegetation. It is therefore a preferred band combination for advanced users wanting to use the view service for various analysis types. In addition, this band combination type for image data with very high resolution is not available via other public accessible view services. It can therefore be regarded as a value-added product for the scientific community and should be made available via the view services.

4.3. Pseudo-true colour layer

As mentioned in section 2.2, a true colour layer would be the best solution for presenting the Core_003 data to a wider user community. Especially casual public users will be better served with true colour-like imagery compared to false colour. But also as background layer behind other geographic data layers, a true colour image layer is better suited.

If the necessary blue band cannot be received from the image provider (question 1, 4 see Chapter 10), an attempt can be made to calculate a blue band (and possibly a green band) based on the available three bands of the Core_003 scenes based on pixel calculations (raster algebra). Various tests were made with the available test datasets, applying various combinations and weightings of input layers for both the blue and the green band. The results have been compared visually to assess which combination achieves the best results.

The combination that turned out to produce good results and a most natural appearance and high image contrast was the following:

$$\begin{aligned}\text{Blue} &= 0.90 * [\text{B1}] - 0.10 * [\text{B3}] \\ \text{Green} &= 0.85 * [\text{B1}] + 0.15 * [\text{B3}] \\ \text{Red} &= [\text{B2}]\end{aligned}$$

Band naming in these formulas relates to original Spot instrument band order. Since the Core_003 data are delivered with band order [321], their bands B1 and B3 need to be swapped for the formulas.

The results comparing false colour and pseudo true colour are shown below for different scales and land cover. They demonstrate that the creation of a pseudo true colour layer using the pixel functions mentioned above is a viable way to offer natural looking satellite imagery through a view service based on the available datasets and band combinations. The creation of the true colour layer with full

reprocessing the scenes or mosaic tiles will double the required storage size. An alternative approach has been tested applying the pixel function on-the-fly. The main drawback of this approach is the higher response times for every WMS request (see chapter 6).

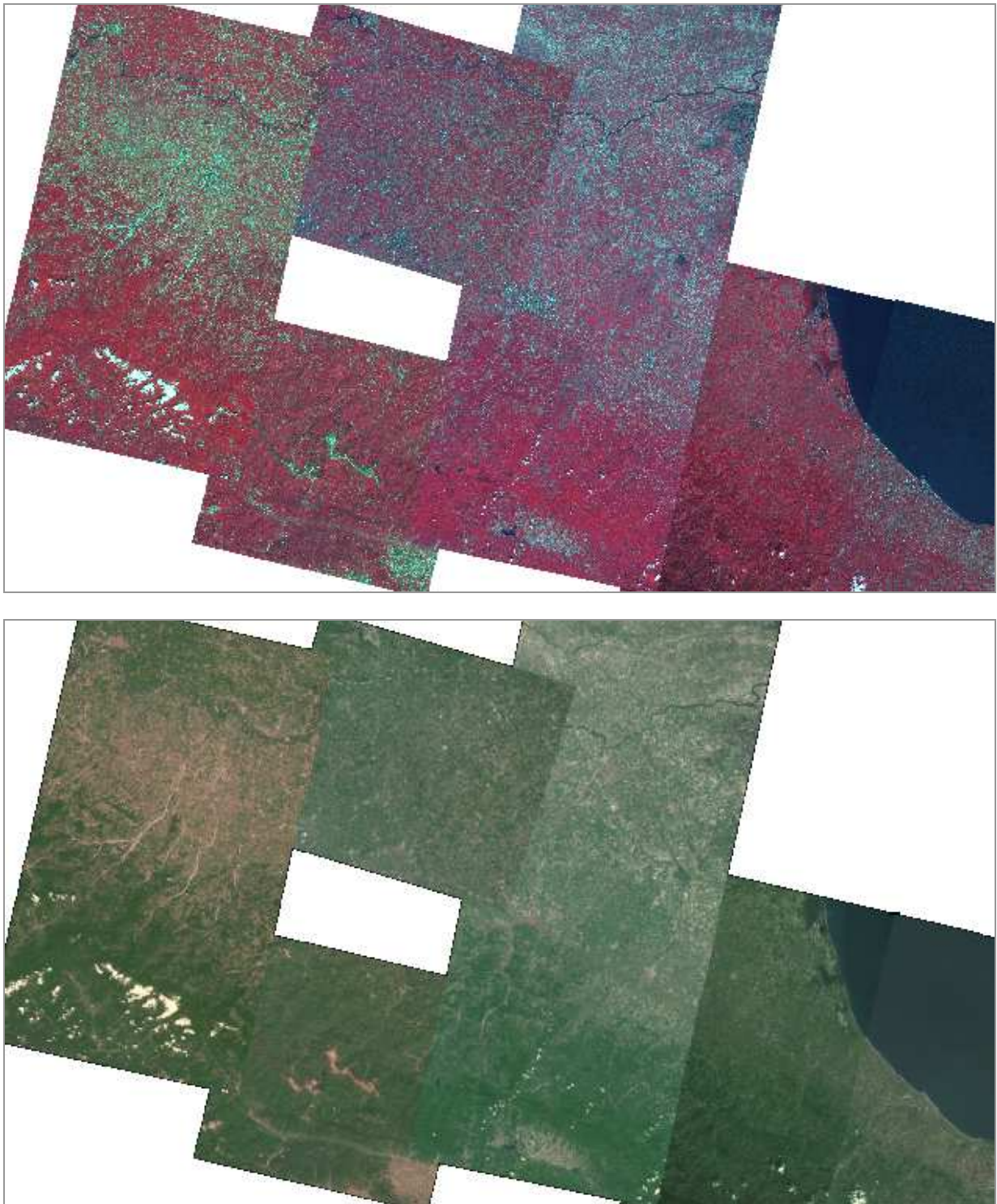


Figure 5 - Overview, scale 1:1500000

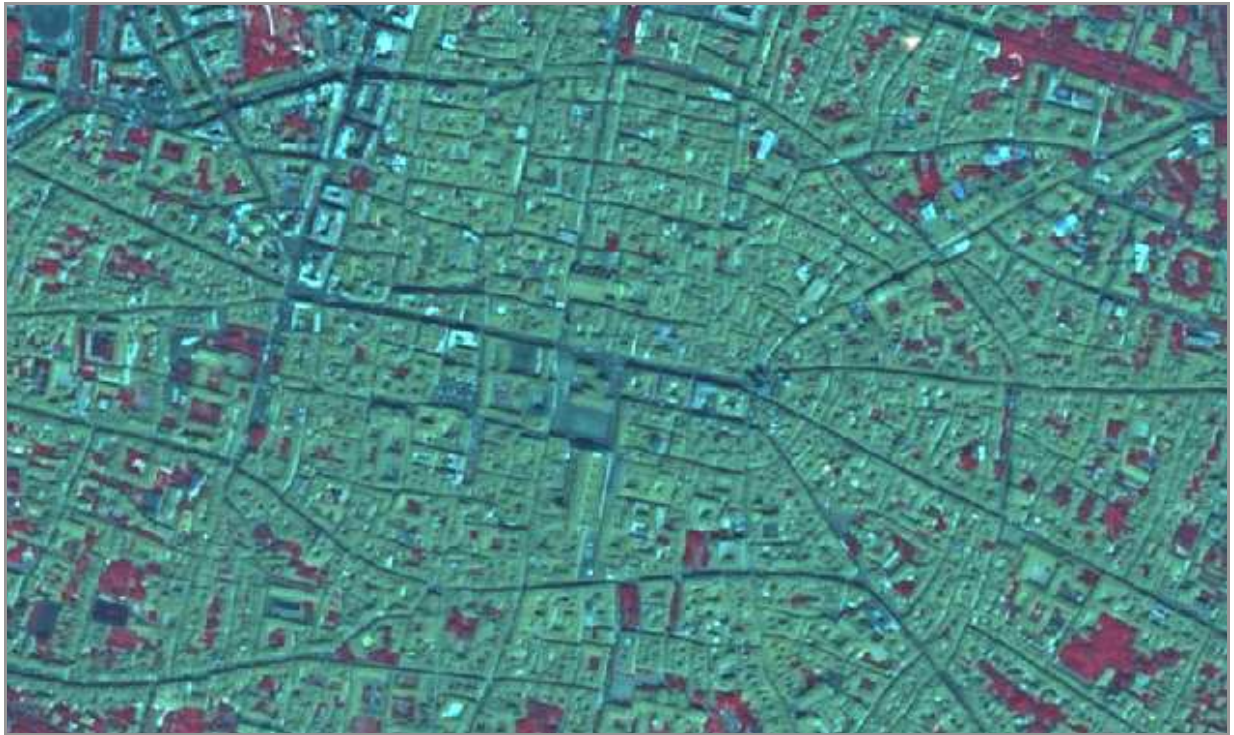


Figure 6 - Urban area, scale 1:12000



Figure 7 - Agriculture area, scale 1:30000

5. Recommended view services set up for the GMES Core_003 VHR2 coverage

As described in Chapter 3, there are different possible services for viewing geospatial datasets, with different use scenarios and each with its own advantages and disadvantages. The WMS service is regarded as the most important implementation due to its versatility and widely implemented specifications. The underlying system and data management layers are the same for all types of services. It is therefore recommended to also set up a tile service based on the WMS, and a Web mapping application on top of this tile service to provide the maximum flexibility for data access and dissemination.

The INSPIRE initiative defines in the “Technical Guidance for the implementation of INSPIRE View Services” [8] two service types to be implemented:

- INSPIRE Profile of ISO 19128 - this corresponds to a WMS service (version 1.3.0, see section below);
- INSPIRE Profile of WMTS 1.0.0.

The recommended view service implementations described in this document cover both of these types. The detailed specifications are described below.

5.1. Web Map Service

The WMS protocol defines different versions with different service implementations. The most recent one is version 1.3.0. This version is extended by the INSPIRE Profile of ISO 19128 [8]. The INSPIRE profile mainly extends the information of the metadata returned by the service *GetCapabilities* response. For the time being there are virtually no software packages that fully implement this INSPIRE profile. Thus a WMS set up will need to address this issue and implement possible solutions.

Compliance with INSPIRE standards is an important goal of the view service set up. Therefore the WMS version 1.3.0 extended by the INSPIRE Profile is regarded as the mandatory implementation of the WMS set up for the Core_003 VHR2 coverage. Since not all client applications have already fully implemented the correct specifications of the WMS protocol version 1.3.0, the system set up should also support the predecessor version 1.1.1 as a fallback solution.

Geo-spatial data are stored in their native coordinate reference systems (projection systems). Loading such data via WMS into clients and in combination with other datasets requires the possibility of the client to either re-project the remote data or request the data in the desired reference system from the WMS server. The WMS protocol defines as mandatory parameter of a data request the definition of the coordinate reference system, usually in the form of specifying the appropriate EPSG code that represents the projection parameters.

The implementation of the WMS for serving the GMES Core_003 VHR2 coverage shall provide support for the pan-European coordinate reference systems based on ETRS89 datum in line with INSPIRE implementing rules [9]. In addition, standard global coordinate reference systems (see Annex) as well as all major national coordinate reference systems used in the countries covered by the Core_003 datasets shall be supported. The full list of supported national projections and the definition of all the projection parameters need to be compiled in agreement with national stakeholders and is available as a working document at EEA.

In order to provide accurate re-projection, the WMS system implemented must support high-accurate 7-parameter datum shift functionality based on default shifting parameters defined in the EPSG database [10].

5.2. Tile service

The INSPIRE guidance document defines a Web Map Tile Service (WMTS) in version 1.0.0 as the second type of view service implementation. The tile service set up for the Core_003 VHR2 coverage shall therefore support this specification. The required tiling scheme, called *TileMatrixSet* for WMTS, is defined as *InspireCRS84Quad* [8]. This corresponds to the standard *GoogleCRS84Quad* set, using geographic projection with WGS84. The difference is that level 0 of the INSPIRE tile matrix set is level 1 of the Google tile matrix set.

For pan-European Web applications the ETRS-LAEA coordinate reference system (EPSG 3035) is widely used. Therefore an additional tile matrix set for this reference system should also be implemented for the Core_003 WMTS set up.

In addition, the tile service shall implement support for the tiling schemes defined by Google Maps and Microsoft Virtual Earth using the Spherical Mercator projection (EPSG 3857/900913) as the most widely used tile schemes for Web mapping applications. This allows the combination with commercial tile services as well as freely available services like OpenStreetMap [11] in Web mapping applications.

Every tiling scheme for every available layer (false colour, true colour) needs to be pre-processed and updated according to major data updates. This requires a clear update strategy and every implemented tiling scheme per layer requires additional disk space in the order of approximately 10 to 20 % of the input scenes. Image formats supported by the tile service can be limited to JPEG only since it is the most suited format for imagery data. Adding support for PNG formats as well will increase the necessary storage space for the tiles by approximately 150 to 200% due to bigger file size of 24 or 32 bit PNG files compared to JPEG.

5.3. Web mapping application

A Web mapping application is regarded as a useful add-on on top of the implemented tile service. It should be based on standard Web libraries that provide enhanced functionality and flexibility for future extension of the Web map application.

The Web mapping application will very likely become the standard access point to the Core_003 datasets for casual users. The Web map application provides in addition a possibility for potential users of the WMS or tile service to quickly view on the available datasets. This way they can check data parameters (like resolution, spectral information) and assess the suitability for certain use cases. In order to improve map navigation and orientation, additional pan-European datasets like NUTS levels, communes, Corine Landcover, etc., as well as publicly available data like OpenStreetMap should be included as separate overlay layers.

A help section shall explain the usage of the tile service inside a Web mapping application for other sites that shall include the data as background layer. Terms and conditions of use of the service shall be available via a direct link from the Web map application.

5.4. Interoperability and correlation between view service types

The diagram below shows the structuring of the service types and how they are correlated with each other. The core service is the WMS with INSPIRE extensions that directly accesses the datasets via the network file system (this can be the single scenes or the processed mosaic). Main access to WMS will be via desktop clients. Access from Web mapping applications that should request the data as tiles should be blocked if direct WMS request is made in order avoid unnecessary load on the server via the WMS protocol. See chapter 7 for more details. An overview about WMS capabilities

can be retrieved by interested users by directly requesting the capabilities XML document via the *GetCapabilities* request, e.g. from within a browser.

The tile service is based on top of the WMS. It pre-processes the tiles and stores them on the network file system. The tile service responds to tile request of clients by returning the requested tile images. The tile services is supposed to be mainly used from within Web map applications, but also desktop clients that are capable of communicating with tile services can access the service.

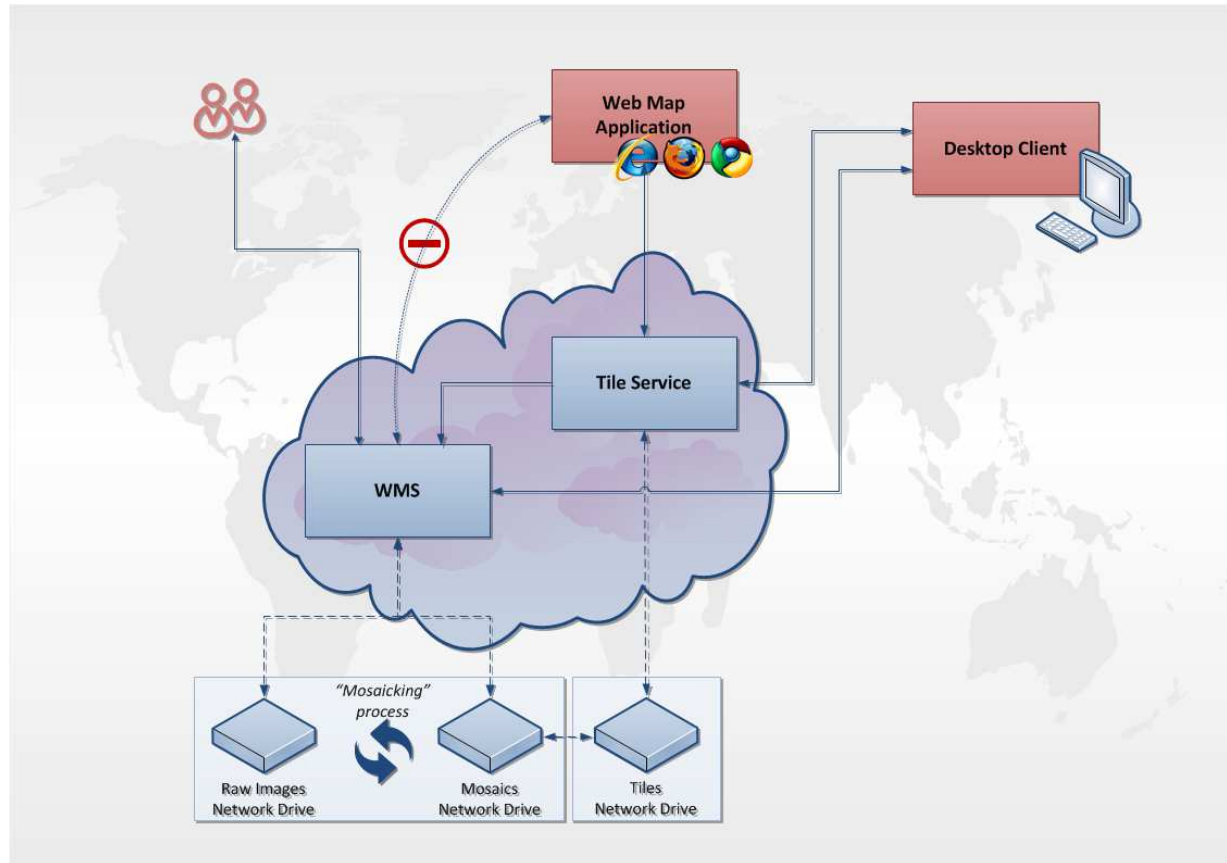


Figure 8 – View service set-up and inter-correlation

6. View service benchmarks

Benchmarking view services is an important assessment of the service quality regarding its responsiveness and hence usability by service users. The INSPIRE Technical Guidance document for view services [8] specifies in the chapter *Quality of Services*, sections *Performance* and *Capacity*, criteria for assessing the service quality. A view service shall be able to handle a *GetMap* request of an average size of *800 x 600 pixels* with a response time of maximum *5 seconds* for at least 90 % of the responses. *The minimum number of served simultaneous service requests to a view service according to the performance quality of service shall be 20 per second*. This shall be measured on a regular basis to continuously monitor and guarantee the service quality.

6.1. Comparison performance WMS - tile service

As mentioned in chapter 3, tile services can serve much more concurrent user requests than WMS services due to pre-processed tiles and caching mechanisms. In order to assess the capacity of each service type, benchmark tests have been performed on the same hardware. The table below shows the parameters used for the benchmark tests.

	WMS	Tile service
Software for services	MapServer	MapCache
Hardware	6-core CPU, 2.66 GHz, 28 GB RAM data on NetApp network storage appliance, access via NFS	
Concurrent requests	5 to 120	100 to 1000
Average size of requested images in pixels	816 x 660 1020 x 830 1240 x 1000	256 x 256
Software for benchmark	wget and Python scripts	ab

Table 1 - Summary table comparing WMS and Tile service performances

6.2. Preliminary tests of WMS for Core_003 scenes

The available 11 Core_003 scenes using 22 image files have been configured as a WMS to measure potential service speeds for the evaluated data. The software package used for the WMS test set up was the OSGEO MapServer [12]. This benchmark can assess only partially the final speed of a WMS serving the full European coverage. It can however give hints about potential capacity of a certain set up and possible shortcomings.

A list of 150 requests has been compiled, each with a different geographic area, scales ranging from 1:10000 to 1:200000. The requests were performed from two to three client machines in the same network environment. Requests were randomly selected from the request list, number of requests per simulated client were 50. The number of concurrent clients was raised step-wise from initial 10 to a maximum of 120, depending on requested image size.

The tests were performed with three different average image sizes for the *GetMap* request (width x height). An average of 816x660 pixels corresponds relatively close to the standard scenario from the INSPIRE document (800x600). For more practical use cases, taking into account modern screen sizes, two additional average image sizes have been benchmarked: 1020x830 (75 % more pixels than INSPIRE standard), 1240x1000 (158 % more pixels than INSPIRE standard).

In order to achieve good performance for low scale/zoom levels, image pyramids (overviews) have been created. In addition, a low-resolution image including the down-sampled content of all full resolution scenes has been created for serving the data at very low scales to avoid the overhead of multiple file access. In the case of the few test scenes this latter optimization would not have been necessary but it will become important when serving several hundreds or thousands of GeoTIFF files. The layer used for the benchmark was the true colour type with the band calculation applied on the fly. The requested projection was EPSG 3035, so no data re-projection had to be applied since this is the original reference system of the datasets.

The results of the benchmark for WMS set up for Core_003 test scenes are shown in the two figures below. The diagram in Figure 9 shows the **average response times** per *GetMap* request for the three different average image sizes. The lowest size (816x660) achieves response times of 0.2 to 2 seconds and remains far below the required 5 seconds from the INSPIRE Technical Guidance document [8], even at very high server load with more than 100 concurrent users. The tests with the two larger image sizes show faster increase of response times when augmenting the number of concurrent requests, but still show acceptable response times for up to 60 concurrent client requests.

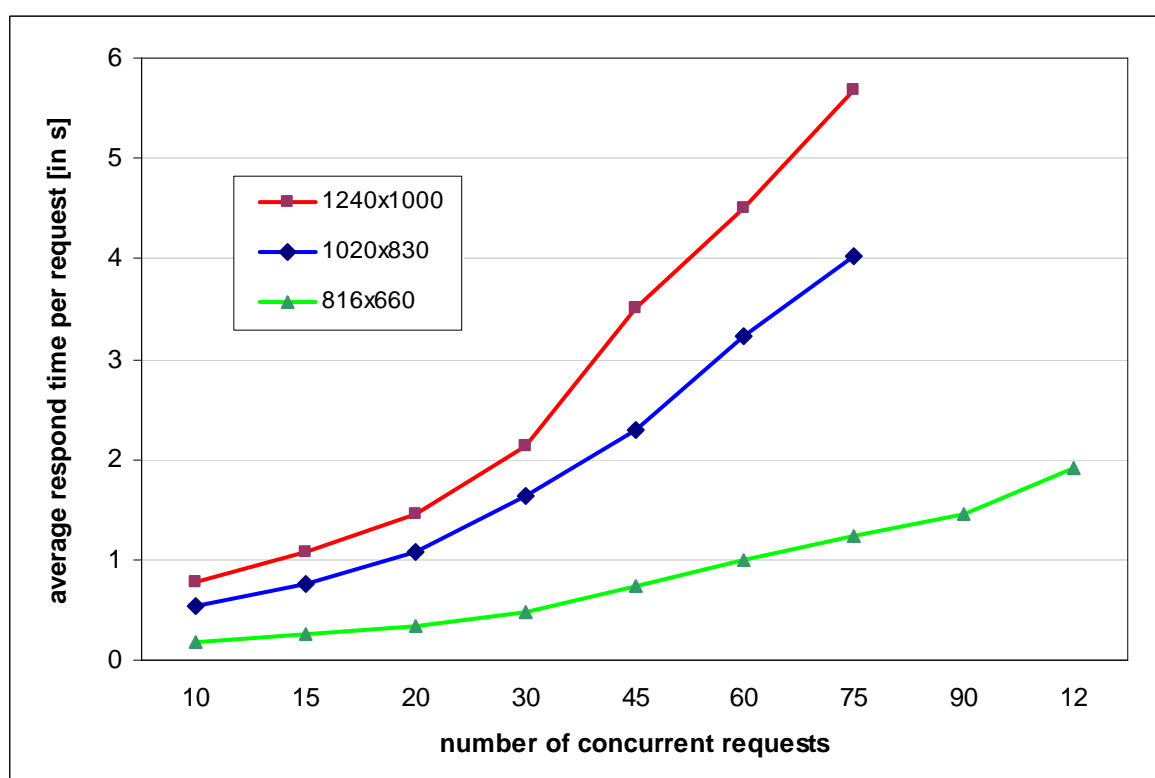


Figure 9 - WMS set up for Core_003 test scenes: average response times per GetMap request

The **maximum throughput** is shown in Figure 10. It reaches very high throughputs for the small image size and supersedes the requirements by the INSPIRE Technical Guidance document [8]. It also shows much higher throughput than the test scenario shown in the table above, especially when comparing the average image size. So the increased server power was transformed to increased number of requests. With the two larger image sizes the service can serve less user requests, but still no decrease of throughput is visible. This means that the server still handles the load well and only the response times are increasing, but a complete overload with decreasing throughput has not happened yet.

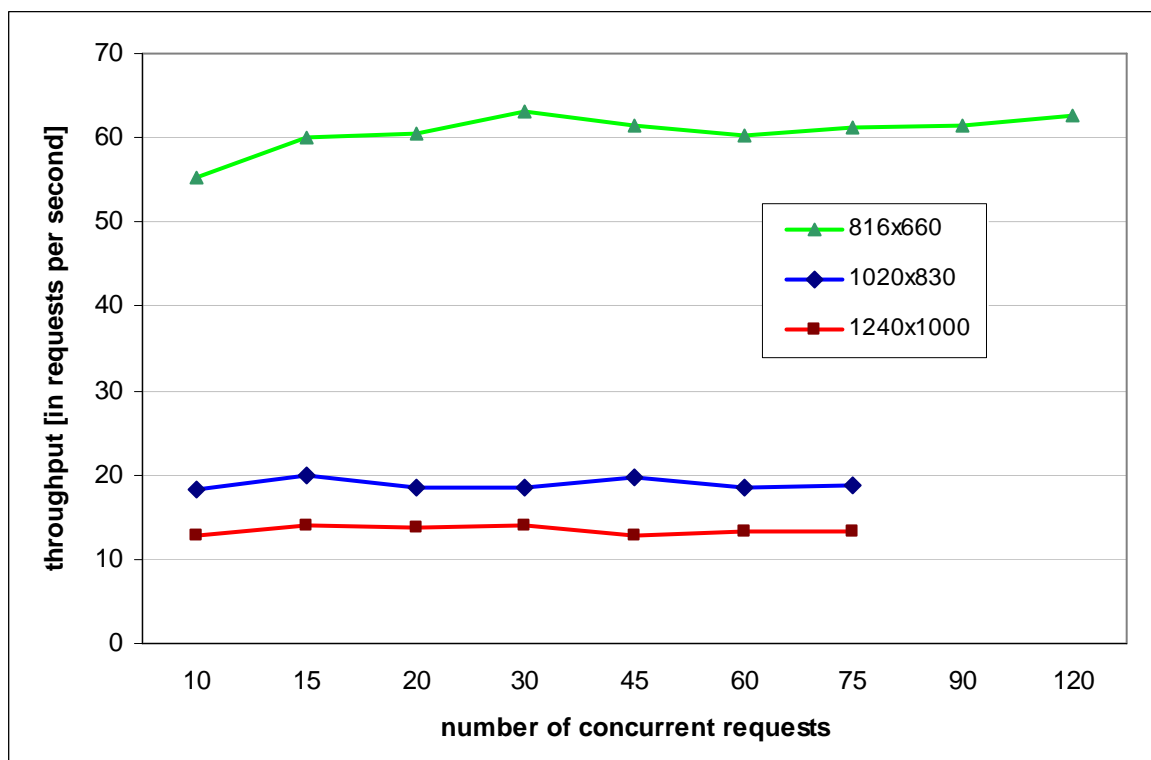


Figure 10 - WMS set up for Core_003 test scenes: throughput in requests per second

The potential performance of a WMS depends also on the **processing parameters** that the service has to apply *on-the-fly* on request/on demand on the data. The Figure 11 shows the impact of pseudo-true colour processing and histogram stretching applied on-the-fly onto the single scenes (test used the 1020x830 average size).

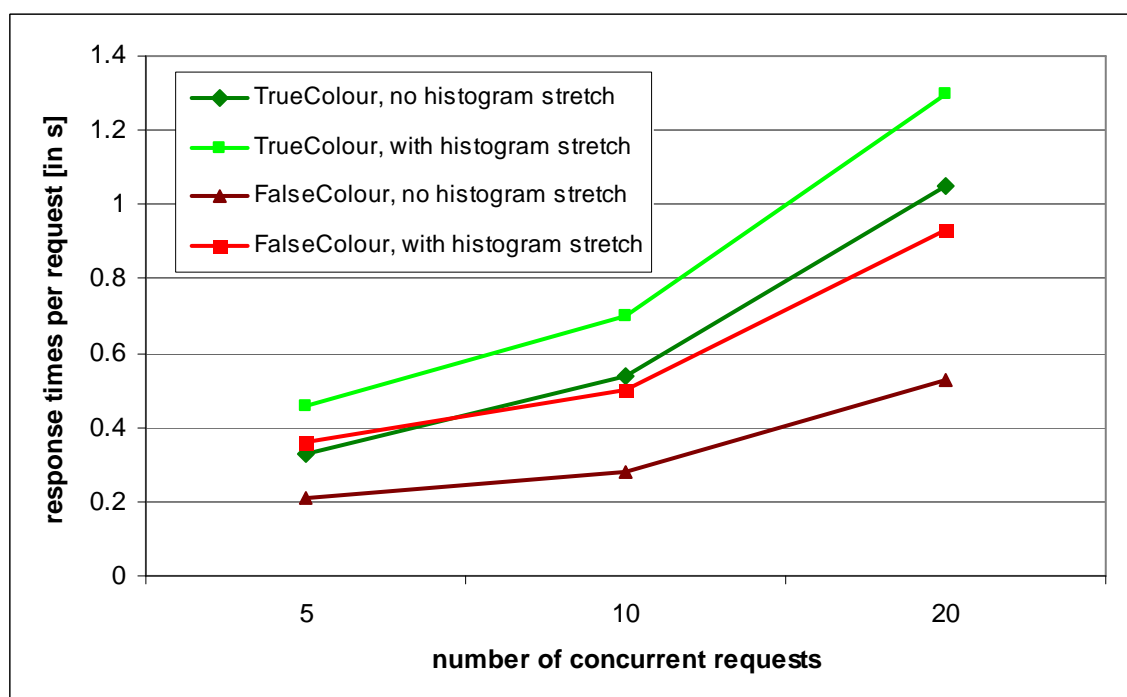


Figure 11 - average response times per GetMap request depending on layer processing type

FalseColour no histogram stretch is reading the data as they are, without any additional processing performed. Every single additional processing parameter applied to the data reduces the performance

and increases average response times per request. This effect becomes stronger the more concurrent requests are performed onto the server.

This fact requires a trade-off between the flexibility of the processing on-the-fly with its storage-saving on one hand, and the higher performance of pre-processed and hence duplicated data on the other hand. A viable compromise could be to use on-the-fly processing for the available datasets until the coverage is complete. And once a full coverage is achieved, all data are fully processed and a second true colour layer is created and stored separately.

It needs to be mentioned that the benchmark results profit from the limited number of scenes. The image and pyramid files are partially cached via file caching mechanisms of the operating system. This will work better for a smaller amount of files due to limited availability of server working memory. For a full coverage the caching effect is expected to be much lower and response times will likely increase. A full estimation of this effect will just be possible with a much higher number of scenes served via WMS. With a total number of 100 and more scenes, a more realistic result could be expected. In addition, the requests in a real world scenario will also include other projections and hence require partially data re-projection on the fly which will also slow down the responses. Nevertheless, the benchmarks showed a good scalability of the tested software set-up and configuration. Increasing server power and the number of servers should provide sufficient potential to deal with increasing number of client requests.

6.3. Benchmark test for tile service

The tests were performed using two tile images: one with 24 Kbyte file size, one with 3 Kbyte file size. The typical size of tiles for satellite imagery should be between these two extremes. The main test was performed via network access from the client machine to the server inside the same network area. In order to estimate the network access as potentially limiting factor, a second test was run directly on the server executing the requests internally via the loopback device. The main focus was put on the average throughput of requests per second. In addition, average respond times for the best 95% of the responses were registered.

The diagram in Figure 12 shows the average throughput in requests per second handled by the server, dependent on the number of concurrent clients and file size of the image tile. The access was performed via the network.

The results show a clear dependency of the throughput related on the tile size. The number of concurrent simulated clients had a limited effect up to a total number of 1000 clients. When analyzing the throughput for the larger tile size, it becomes clear that the limiting factor is the network speed. The measured maximum throughput traffic was up to 105 Mbyte/s which is close to the limit of the Gigabit network protocol. The maximum throughput for the smaller tile size is very likely due to network I/O limitations.

Running the requests directly on the server via the loopback device increases the maximum achievable throughput to 18000 requests/s for the 24 Kbyte tile and to 20000 requests per second for the 3 Kbyte tile. This corresponds to traffic throughput of 420 Mbytes/s and 55 Mbytes/s. So especially for the larger tile size the limiting factor seems to be the speed of the network. A potential tuning parameter could be to use multiple network cards on the server working in bonding (=teaming) mode if this is supported by the network infrastructure.

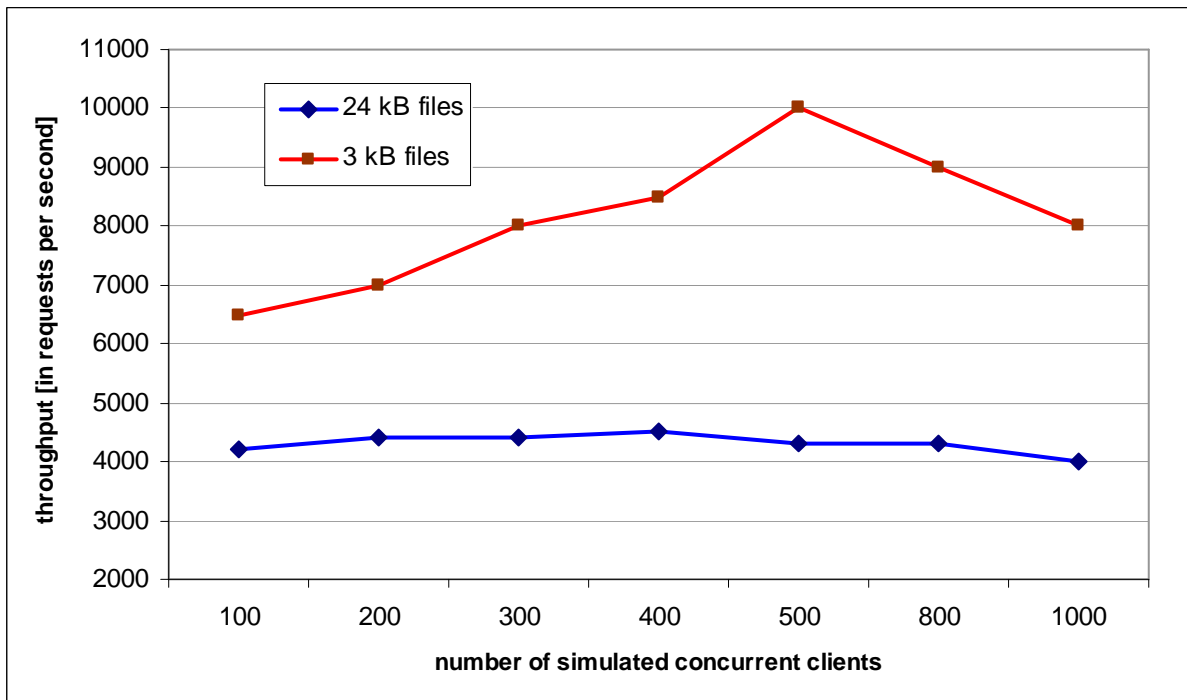


Figure 12 - average throughput of a tile service

The average response times of a tile request are an important parameter to assess the quality of service with regards to responsiveness. The diagram in Figure 13 shows the average response times for a 24 Kbyte image tile for the best 95% of the requests, depending on number of concurrent clients.

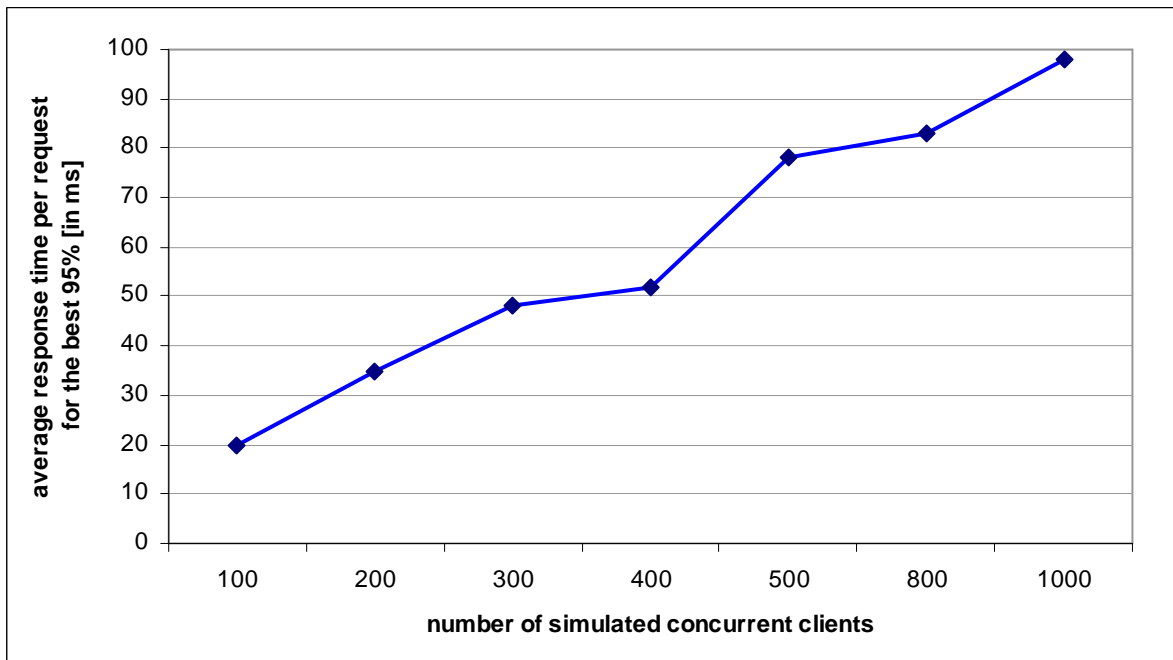


Figure 13 - Average response time per tile request for the best 95% (for 24 Kbyte image tile)

The slowest 5% of responses were usually in a magnitude of 5 to 10 times slower than the best 95%. Especially for tile services the value that counts most is the response time of the best 90 to 95% since clients start to show tiles already when the first are fully loaded. This way tiles that take a longer time to be loaded do not cause long waiting times. The measured average response times of below 100

milliseconds up to 1000 for concurrent clients should guarantee sufficient responsiveness of the service.

6.4. Benchmark comparison between WMS and tile service

The results show clearly the advantage of tile services towards WMS for serving data to high numbers of concurrent users. An 816x660 pixel image retrieved via WMS corresponds to approximately 8 tiles with 256x256 pixels each. Taking into account these sizes, a tile service can serve around 10 to 15 times more requests than a WMS on the same hardware. In addition, when used via Web map applications, tiles with a fixed naming scheme are cached by the browser and are not requested any more from the service when the user navigates back to an area and zoom level he already was before. This mechanism will additionally reduce the load to the service by an estimated factor of 50 to 100%.

Tile services are therefore the highly recommended mode of access to the Core_003 via Web map application. WMS access should therefore mainly be limited to requests via desktop clients or Web map applications that load single images instead of multiple tiles. See also chapter 8 for more details regarding this issue.

7. Service reliability, scalability and monitoring

7.1. Service reliability

The recommended view services shall be implemented in a fail-safe system set-up in order to reduce risks of service downtimes. All components shall as much as possible be set up in a redundant infrastructure to avoid single points of failure. Hardware for data storage and software shall be of enterprise level. The implementation of a health monitoring system is recommended to early identify failures at the various system levels (network, hardware, software) and to allow a timely intervention.

The INSPIRE Technical Guidance document for view services [8] specifies in the chapter *Quality of Services*, section *Availability*, guidelines for the reliability based on system availability over time: *The probability of a Network Service to be available shall be 99% of the time*. This corresponds to average maximum system downtimes of 1.7 hours per week, 7.27 hours per week, and 3.63 days per year.

7.2. Service scalability

The amount of requests the view services shall be able to handle is very difficult to estimate since they will be open to public access. It is assumed that during the time the services will be active, more and more users will access the services and more Web sites will include them as options for serving the GMES data as background layers. It is therefore indispensable that the system set-up can scale well towards increasing numbers of map requests. This can be best achieved by a highly scalable load-balancing set-up. The set-up shall allow to easily adding more servers to the available server pool in order to cope with the increasing number of requests.

It is assumed that the system will be launched gradually, and not by a “European wide press release” so as to allow a smooth scaling towards increasing number of users.

7.3. Service monitoring and analysis

The number of requests and average respond times of the services for returning map images shall be monitored with adequate benchmarking and analysis tools (see also section 6). These figures are essential for assessing the necessity to increase the amount of servers of the pool to serve possibly increasing number of requests with acceptable response times. In addition, usage statistics reports (via both a Web system and monthly reporting documents) shall be provided to allow analysis of data requests based on various parameters (service types, requested projection systems, requests based on countries, etc.).

8. Security, service usage conditions and restrictions

The view services set-up for the Core_003 datasets are intended to be open for public access. Therefore no mechanisms for user authentication and authorization are regarded as necessary.

As mentioned in the benchmark results in chapter 6, the access to WMS is causing much higher load onto the service hardware than access to the tile service. This is especially the case for Web map applications that request small tiles via WMS protocol. This will cause unnecessary load onto the server since this type of application is better suited to directly use the tile service that shall be made available especially for this use case.

It is therefore necessary to set up mechanisms that block at a low level the access from Web map clients to the WMS using multiple tile requests. In addition, blocking mass download of images from the WMS, e.g. via a scripting approach, is a requirement of the data usage terms and conditions. This requires an analysis of the traffic and book-keeping for any accessing client.

A conspicuous, not suppressible logo and attribution of the EC/GCME shall be added to every image returned by the WMS. The tile service shall include a watermark on every tile that ensures sufficient attribution of the EC/GCME as provider of the service.

Clearly defined terms and conditions for the usage of the service shall be set up. They shall take into account the aforementioned recommended usage restrictions. The terms and conditions of the services shall be made available via a public web site that provides also the entry point with links to the various services. The *GetCapabilities* response of WMS and WMTS shall list in the service *Description* and *Abstract* part a short version of the terms and conditions and a link to the main web site for detailed information. It is being discussed with ESA which EULA should be presented (see Chapter 9)

9. Data Licensing

9.1. GIO DWH Licensing

The licensing for the CORE_003 is described in the EC DWH Requirements document [1], and in the GMES Space Component Data Access Portfolio [2]: *A VIEW service to the PUBLIC is an option*. This option has been purchased by the EC through ESA.

There are some constraints with regards to the access rights to the CORE_003 by Public Authorities in Turkey which is being solved, and further some constraints on making the specific VIEW service available to the PUBLIC in Turkey which should however be waived latest in November 2012.

The issue of whether the EC through JRC (an Institution and body of the EU) has the right to provide a VIEW service to the PUBLIC at full resolution, needs clarification vis-à-vis ESA and SPOTImage. The right has to be made possible either through a validated interpretation of the ruling EULA between ESA and User [13], or through sub-licensing by ESA to JRC of the ruling EULA between the GCME - ESA [14]. This discussion is currently ongoing (question 6 see Chapter 10).

10. Summary of issues to clarify with DG ENTR, ESA, SPOT Image and EEA.

- 1.) There are discrepancies in the CORE_003 specifications between the EC DWH Requirements document [1] and the GMES Space Component Data Access Portfolio document [2]. How was it transferred from one document to the other? Who approved the ESA document? e.g. not all visible bands are delivered i.e. blue synthetic band missing; the non-orthorectified imagery should also be made available... Clarification to be asked from ESA. Can then a contact be made with SPOTImage to understand whether ancillary data, or by products, are available?
- 2.) How is the quality control made of the CORE_003 product? ESA? GSP? JRC can propose Maussane for an external geometric check.
- 3.) Grid reference to centre of pixel - this needs to be cleared with SPOTImage
- 4.) With the pan-merging already performed, the calculation of the BLUE synthetic becomes more difficult. This reduces quality of the natural colours available for the VIEW service. The possibility to obtain all source data (Bundle PAN plus 4 bands) should be investigated with ESA and SPOTImage.
- 5.) Mosaicking issues (see above) - the fact that a pan-merging has been applied makes the mosaicking more difficult.
- 6.) Licensing (ref emails of Thierry B to Bianca H, dated 5/02/2012; Bianca H answer of 29/03/2012; new questions by Thierry B, after input from JRC, on 30/03/2012; new answer by Bianca H on 30/03/2012). A teleconference in the matter is preliminary planned for the 16/04/2012.
- 7.) It is moreover suggested to make a preliminary work schedule in agreement between DG ENTR, the EEA and the JRC for an efficient setup of the requested VIEW service (i.e. mosaicking, service setup etc.) [ref MoM JRC/EEA teleconference of 23/03/2012, JRC IES/H04/C/PAR/gma D(2012)(14517)]

11. References

- [1] GMES Data Access (Data Warehouse Requirements V1.8, DG ENTR, 2010).
- [2] GMES Space Component Data Access Portfolio: Data Warehouse 2011-2014 (ESA ref. GMES-PMAN-EOPG-TN-11-0006, version 2.3, 08/12/2011)
- [3] Specifications for a view service for GMES Core_003 VHR coverage JRC IES/H04/C/PAR/abu D(2011)(14099) / file://S:\FMPArchive\C\14099.doc
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- [6] Open Geospatial Consortium (OGC), <http://www.opengeospatial.org>
- [7] OpenGIS Web Map Tile Service (WMTS), <http://www.opengeospatial.org/standards/wmts>
- [8] Technical Guidance for the implementation of INSPIRE View Services
http://inspire.jrc.ec.europa.eu/documents/Network_Services/TechnicalGuidance_ViewServices_v3.1.pdf
- [9] Commission Regulation (EU) No 1089/2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services.
<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2010R1089:20110225:EN:HTML>
- [10] <http://www.epsg.org>
- [11] OpenStreetMap, <http://www.openstreetmap.org>
- [12] OSGEO MapServer software suite, <http://www.mapserver.org>
- [13] Sub-licence ESA - User; Multiple-User and -usage Sub-licence for EO data from the GSC-DA, Terms and Conditions (version 1 31/05/2011)
- [14] License GCME - ESA; Terms and Conditions (Appendix 2:V to ITT based on EC - ESA Agreement "Implementation of the Space Component of Global Monitoring for Environment and Security (GMES)")

12. ANNEX

Coordinate reference systems support for WMS implementation

Pan-European Projections based on ETRS89

ETRS geographic, EPSG 4258

ETRS Lambert Equal Area, EPSG 3035

ETRS Lambert Conformal Conic, EPSG 3034

ETRS ETM projections, EPSG 25828 to 25838

Standard Global Projections

WGS84 Geographic Projection, EPSG 4326

UTM WGS84, EPSG 32628 to 32638

EU National Projections

A list of national projections with their datum shift parameters ($=TO_WGS84$) is available as working document from EEA.



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Abstract

For the so-called DataWareHouse concept (DWH) within the GMES Initial Operations period 2011-2014, data access management is funded through a Delegation Agreement between the EC and ESA. The Core_003 VHR2 dataset is one of the satellite coverages that are defined as CORE datasets within the DWH with fixed specifications which will be offered to a broad range of users and activities. JRC was asked by DG Enterprise to provide technical specifications for the implementation of a view service for the Core_003 datasets as part of the Administrative Arrangement n. 5 between DG Enterprise and JRC. This report provides an overview about different view service types with their specific characteristics and use cases. Since compliance with INSPIRE implementing rules is a goal to be achieved by GMES services, the specific requirements of INSPIRE for view services have been taken into account. The Core_003 datasets have been analysed with regard to their parameters that are important for the inclusion in view services. Based on the results of the analyses, recommendations are given for the implementation of the view services as well as for the data processing and configuration of the Core_003 datasets.

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